SURVEY OF AND EVALUATION OF CONTINUOUS ANALYZERS FOR RESIDUAL AMMONIA IN FLUE GAS

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Introduction

Ammonia-based postcombustion NOx control can be viewed as an exchange between NOx removed from, and residual ammonia introduced into, boiler flue gas. One method to maximize NOx reduction is to operate at maximum permissible flue gas residual NH_3 content. A continuous analyzer to determine residual ammonia content supports this control strategy. However, despite limited success with natural gas-fired applications, there are no commercial ammonia monitors proven for the wide range of U.S. coals. Wet chemical methods, although broadly deployed, are costly due to their labor-intensive nature, and the quality of results depends on precise methods execution. Also, the significant delay in obtaining results (~hours) eliminates opportunity for using this method for process control.

EPRI has initiated a broad program to identify and mitigate balance-of-plant impacts of postcombustion NOx control on fossil fuel fired boilers. The EPRI program includes improvements to instrumentation/controls, and presumes a commercial monitor for residual ammonia will be available. EPRI will initiate in 1997 the first of several performance trials to evaluate ammonia monitors at various coal-fired utility sites, and is presently considering test candidates.

Objective

The objective of this study is to identify continuous ammonia monitors with potential to provide alternatives to conventional wet chemistry methods.

Approach

Approximately 20 instrument manufacturers (listed in the paper) offer a commercial monitor, either operating in the field or in demonstration. These manufacturers were contacted regarding principle of operation, commercial experience with various fuels, and approximate cost. The relative strengths and weakness of each type of instrument were discussed.

This study is not intended to select a preferred instrument(s) for utility application. It is anticipated that many analyzers, which are in varying development stages, will find a successful application "niche". EPRI will provide an arena for selected instruments identified in this study to test and improve their products, using authentic utility conditions.

Results: Categorization of Monitors

Five categories of monitors, defined based upon the principle of detection, account for most instruments. These monitors employ either extractive sampling (flue gas sample withdrawn from the duct, and transported to a remote analyzer) or in-situ sampling (optical detectors located within the duct). The five categories of monitors are:

Inference from NO. These extractive devices oxidize ammonia to NO, with the difference in NO prior to and after conversion being indicative of ammonia concentration. Instruments in this category are relatively simple and use conventional and proven equipment (e.g., thermal converters, chemiluminescent analyzers), but are susceptible to inconsistent ammonia conversion, and loss of ammonia as salts during

sample transport.

UV Absorption. These extractive or in-situ devices detect absorption of UV light. Individual manufacturers utilize different spectral regions to avoid interference from SO_2; at least one manufacturer employs a laser source to "target" a narrow spectra. Instruments are also differentiated by the method to detect light exiting the sample cell, employing devices such as photomultiplier tubes and linear diode photo arrays. These monitors features a strong absorption characteristic for ammonia, producing a signal with favorable signal/noise ratio and thus high sensitivity. The disadvantage is interference by SO_2; correction methods have been devised but are not fully proven for medium-high sulfur fuels.

IR Absorption. These extractive or in-situ devices detect absorption of IR light. Most monitors employ different spectral regions, selected to maximize sensitivity and avoid interference from CO_2 and H_2O, and also employ different methods to detect light exiting the sample cell (e.g., gas filter correlation, dual wavelength, and FTIR). These monitors also can employ a laser source to target a narrow spectra and further minimize interference. The advantage of IR instruments is the lack of SO_2 interference; however IR absorption characteristics are not strong (compared to UV) and detection limits may be compromised.

Ion Mobility Spectroscopy (IMS). IMS techniques employ a weak radioactive source to ionize a flue gas sample, thus imposing a charge and inducing a migration velocity when exposed to an electric field. This unique migration velocity is used to segregate molecules. The instrument manufacturer claims this extractive-only method completely avoids interference, as the migration velocity is unique among different flue gas constituents. The disadvantage of this monitor is the large number of sample and signal processing steps which may be prone to error and compromise reliability.

Automated Specific Ion Electrode. Three monitors essentially automate the wet chemical sampling concepts based on the specific ion electrode, including automated sample acquisition, reagent addition, and detection/analysis. The advantage of these instruments is use of well defined methodologies; the disadvantage is the large number of process steps.

Status of Application/Experience

These results show a variety of instruments are available, each offering a range of experience and cost. Approximate cost ranges from <$20 K (two inference NO probes that operate with chemiluminescent analyzers) to $125-200K (selected in-situ monitors that analyze multiple species).

Most suppliers cannot provide a sufficient experience base to allow a thorough and independent evaluation of measurement reliability, precision, and relative accuracy. Several field trials have been broadly reported where continuous monitor results have been compared to wet chemical data; these results do not satisfy the requirements for a comprehensive analysis but are insightful. These are:

   New England Power/Salem Harbor, where an in-situ UV instrument (Spectrum Diagnostix) operated downstream of SNCR for several months,

   Public Service New Hampshire/Merrimack, where an in-situ UV instrument (Novachem) provided data for comparison with a one day trial with wet chemical results,

Public Service Company of Colorado/Arapahoe, where an in-situ broad spectra IR (Perkin Elmer) operated for over a year, and an in-situ diode IR laser (Monitor Labs) performed for several months.

Other trials conducted include: (a) an inference NO instrument (Monitor Labs) at the Plant Crist SCR Demonstration, (b) two automated wet chemical instruments (Bran+Luebbe and Tess-Com) at Penelec's Seward Station, and (c) two in-situ monitors (OPSIS and SICK) at Public Service Electric & Gas Corporation's Mercer Station. Results from these trials either have not been publicly released or are not broadly available.

Subsequent Activities

EPRI is sponsoring field trials to provide independent, documented experience over a wide range of authentic conditions. Approximately 2-4 instruments will be operated at two utility sites, monitoring residual ammonia at the air heater inlet and outlet. A two phase program will be conducted, the first a 4 month "endurance" trial to evaluate signal reliability, independent of relative accuracy or precision. Instruments that provide a reliable signal 90% of the operating period will participate in a second phase of 6-10 months, where periodic campaigns to compare data with wet chemical results will be conducted.

The first site is Orlando Utilities Stanton Station, with demonstration anticipated to begin by mid-summer 1997 and last approximately one year.